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LANDSAT FOLLOW-ON EXPERIMENT - GULF OF MEXICO
MENHADEN AND THREAD HERRING RESOURCES INVESTIGATION

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February 1976

Type II Report for Period October 31, 1975 - January 31, 1976

Prepared for
GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland 20771

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LANDSAT FOLLOW-ON EXPERIMENT - GULF OF MEXICO
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16. Abstract An investigation is being conducted cooperatively by Federal and State Government agencies and private industry to demonstrate the feasibility of using satellite data for enhancing the management and utilization of coastal fishery resources in the northern Gulf of Mexico. Menhaden (<u>Brevoortia patronus</u>) and thread herring (<u>Opisthonema oglinum</u>) were selected as target species in study areas located in the Mississippi Sound and off the coast of Louisiana. Correlations are being sought between the fishery resources and oceanographic parameters measurable from aerospace platforms from northern Gulf of Mexico. Preliminary analyses suggest a persistent relationship between menhaden distribution and LANDSAT MSS data. A two-class supervised classification procedure has been used successfully which classifies the water scene into high and low probability fishing areas.			
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PREFACE

This progress report covers the investigative period from October 31, 1975 to January 31, 1976 and represents the third one prepared since the investigation was formally initiated on April 29, 1975. Emphasis in the first two reports was given to organization, experimental rationale and design, and field operations. This report emphasizes results of initial analytical efforts.

An analysis of LANDSAT MSS data acquired on May 20, 1975 for the Mississippi Sound test site indicates a persistent relationship between menhaden distribution and water color. This relationship appears to lend itself to analysis through a two-class supervised classification technique which divides the scene into high and low probability fishing areas. Additional analyses are being employed to further define this relationship and to test it for the Louisiana test site.

TABLE OF CONTENTS

	<u>Page</u>
1. INTRODUCTION	1
1.1 Reporting	1
1.2 Overview	1
1.3 Objectives	1
2. INVESTIGATION PARTICIPANTS	2
2.1 Principal and Co-Investigative Participants	2
2.2 Associated Groups and Agencies	2
3. SUMMARY OF EARLIER REPORTS	3
3.1 Organization and Responsibilities	3
3.2 Experimental Rationale and Design	4
3.3 Field Operations	4
3.4 Data Processing and Analysis	10
4. ACCOMPLISHMENTS	10
4.1 Data Processing	10
4.2 Data Analysis	17
4.2.1 Remote Salinity Analysis	17
4.2.2 LANDSAT Classification Analysis	17
4.2.3 LANDSAT Statistical Analysis	19
4.2.4 Sea Truth	20
4.3 Future Plans	24
5. SIGNIFICANT RESULTS	24
6. REPORTS, PUBLICATIONS, AND MEETINGS	24
7. PROBLEMS	25
8. RECOMMENDATIONS	26
9. FUNDS EXPENDED	26
10. LANDSAT DATA	26
11. AIRCRAFT DATA	28

LIST OF ILLUSTRATIONS

<u>FIGURE</u>	<u>TITLE</u>	<u>PAGE</u>
3.1	Summary of Data Acquisition Platforms and Parameters	5
3.2	Louisiana Study Area Showing the LANDSAT Track, Aircraft Flight Lines, Oceanographic Stations and Oil Platform Locations	6
3.3	Mississippi Sound Study Area Showing the LANDSAT Track, Aircraft Flight Lines, and Oceanographic Stations	7
3.4	Summary of Louisiana Test Site Missions	8
3.5	Summary of Mississippi Sound Missions	9
4.1	Platform and Data Flow Status Summary for April 25, 1975 Louisiana Main Day Mission	11
4.2	Platform and Data Flow Status Summary for the May 2, 1975 Mississippi Sound Main Day Mission	12
4.3	Platform and Data Flow Status Summary for the May 13, 1975 Louisiana Main Day Mission	13
4.4	Platform and Data Flow Status Summary for the May 20, 1975 Mississippi Sound Main Day Mississippi Sound Main Day Mission	14
4.5	Platform and Data Flow Status Summary for the August 20, 1975 Louisiana Main Day Mission	15
4.6	Platform and Data Flow Status for the September 5, 1975 Mississippi Sound Main Day Mission	16
4.7	Comparison of Surface Measurements of Chlorophyll-a from Sites of Menhaden Capture and Oceanographic Stations in the Louisiana Test Site	21
4.8	Comparison of Surface Measurements of Chlorophyll-a from Sites of Menhaden Capture and Oceanographic Stations in the Mississippi Sound Test Site	22
4.9	Summary of Measurements Taken at Sites of Menhaden Capture for the Two Study Areas	23

LIST OF TABLES

<u>TABLE</u>	<u>TITLE</u>	<u>PAGE</u>
4.1	Limits of Classification Ranges for May 20, 1975, and August 7, 1972, Mississippi Sound Missions	19
4.2	Correlation Between LANDSAT Spectral Channels and Menhaden Distributions	19
10.1	Summary of LANDSAT Data Status	27
11.1	Aircraft Data (NP3A) Status	29

ABBREVIATIONS AND SYMBOLS

NASA	National Aeronautics and Space Administration
NMFS	National Marine Fisheries Service
NFMOA	National Fish Meal and Oil Association
LANDSAT-1	Land Satellite (No. 1)
LANDSAT-2	Land Satellite (No. 2)
JSC	Johnson Space Center
ERL	Earth Resources Laboratory
FEL	Fisheries Engineering Laboratory
NOAA	National Oceanic and Atmospheric Administration
NESS	National Environmental Satellite Service
NWS	National Weather Service
AOML	Atlantic Oceanographic and Meteorological Laboratory
GSFC	Goddard Space Flight Center
NSTL	National Space Technology Laboratories
USGS	United States Geological Survey
EROS	Earth Resources Observation Systems
OCSO	Outer Continental Shelf Operations
USCG	United States Coast Guard
NP3A	NASA Medium Altitude Remote Sensing Aircraft
SMS/GOES	Synchronous Meteorological Satellite/Geostationary Operational Environmental Satellite
LLTV	Low Light Level Television
ISRS	Information Storage and Retrieval Systems
PRT-5	Precision Radiation Thermometer-5
MSS	Multispectral Scanner System
ERTS	Earth Resources Technology Satellite
MFMR	Multifrequency Microwave Radiometer
M ² S	Modular Multispectral Scanner
CCT	Computer Compatible Tape
A/D	Analog to Digital
PCM	Pulse Code Modulated

LANDSAT MENHADEN AND THREAD HERRING RESOURCES INVESTIGATION

1. INTRODUCTION

- 1.1 REPORTING. This progress report is the third in a series under NASA Agreement Number S-54114, ID #20770, sponsored by the NASA Goddard Space Flight Center. It is a type II report covering the investigative period from October 31, 1975 to January 31, 1976.
- 1.2 OVERVIEW. This investigation is being conducted in two test sites off the coasts of Mississippi and Louisiana. The primary target species is the Gulf menhaden (Brevoortia patronus); the secondary target species is the thread herring (Opisthonema oglinum). Both species form large schools with numbers frequently exceeding one hundred thousand per school. The schools are considered near-surface pelagics which suggests an immediate application of remote sensing techniques. Both species are harvested for conversion into high protein fish meal and oils. Approximately 600,000 tons of menhaden are taken from the Gulf annually representing almost 26 percent of the entire domestic harvest of all fish. While the standing stock of thread herring in the Gulf is believed to exceed that of the menhaden, the catch averages less than 1 percent of the average menhaden landings. The thread herring is truly a latent resource and one which is beginning to receive increased attention from several fishing companies.

The investigation was formally initiated on April 29, 1975, by a memorandum from the Director of the National Marine Fisheries Service to Mr. L. H. Meredith, Assistant Director, Goddard Space Flight Center, in which the Director stated, "the National Marine Fisheries Service is pleased to accept this new agreement (No. S-54114 ID #20770)..." Unofficially, however, the investigation began back as early as November 1974 when a series of meetings began with representatives of the National Fish Meal and Oil Association. These meetings were designed to formulate a plan with the industry for the investigation and in particular to acquire their interest and support.

The investigation was designed to extend over an 18-month period with the first 6 months dedicated primarily to planning and data acquisition (field operations), and the remaining 12 months used for data analysis and report preparation. This third in a series of type II progress reports emphasizes the initial analytical efforts of the investigation.

- 1.3 OBJECTIVES. The primary objective is to verify the relationship of certain coastal environmental parameters which are observable from aerospace platforms to the distribution and abundance of Gulf menhaden, a commercially important fish in the northern Gulf of Mexico. A secondary objective is to establish relationships of remotely sensed environmental parameters to a fish with potential commercial importance, thread herring.

Sub-objectives of the multi-phased investigation are:

- Confirm utilization of aerospace data as inputs for a distribution prediction model for adult menhaden in the Mississippi Sound.
- Test utilization of aerospace data as inputs for a distribution prediction model for adult menhaden over the entire season of menhaden availability in the Mississippi Sound.
- Test utilization of aerospace data as inputs for a distribution prediction model for adult menhaden throughout the commercial fishery range in the northern Gulf of Mexico.
- Test utilization of aerospace data as inputs for a distribution prediction model for adult thread herring off the coast of Louisiana.
- Continue development of techniques for the application of remote sensing data to living marine resource assessment and utilization.

2. INVESTIGATION PARTICIPANTS

- 2.1 PRINCIPAL AND CO-INVESTIGATIVE PARTICIPANTS. This experiment is a cooperative venture whose principal participants originate from various Federal agencies and commercial fishing companies. They are as follows:

National Oceanic and Atmospheric Administration (NOAA)

National Marine Fisheries Service (NMFS)

Southeast Fisheries Center

Fisheries Engineering Laboratory

Pascagoula Laboratory

National Aeronautics and Space Administration (NASA)

Earth Resources Laboratory (JSC/ERL)

National Fish Meal and Oil Association (NFMOA)

- 2.2 ASSOCIATED GROUPS AND AGENCIES. Various groups and agencies who have and are providing assistance in one form or another to the Principal and Co-Investigative elements within the experiment are as follows:

National Oceanic and Atmospheric Administration (NOAA)

National Marine Fisheries Service (NMFS)

Southeast Fisheries Center

Miami Laboratory

Atlantic Estuarine Fisheries Center

National Environmental Satellite Service (NESS)

National Weather Service (NWS)

Atlantic Oceanographic and Meteorological Laboratory (AOML)

National Aeronautics and Space Administration (NASA)

Johnson Space Center (JSC)

Goddard Space Flight Center (GSFC)

National Space Technology Laboratories (NSTL)

Department of the Interior

United States Geological Survey (USGS)

Earth Resources Observation Systems (EROS)

Outer Continental Shelf Operations (OCSO)

United States Coast Guard (USCG)

Nicholls State University

Four Oil Companies

3. SUMMARY OF EARLIER REPORTS

As the first two progress reports emphasized organization, responsibilities, experimental rationale, methodology, field operations, and preliminary analyses, these subjects only will be reviewed in this one. The reader is encouraged to refer to these reports if this summary does not provide enough detail for his particular purpose.

- 3.1 ORGANIZATION / ID RESPONSIBILITIES.** The organization consists of a principal investigator who provides overall guidance to the investigation, and the three principal participants (ERL, NFMOA, and SEFC). Responsibilities of ERL include acquisition of aerospace remotely sensed data and conversion of these data into measurements of selected oceanographic parameters. The NFMOA is responsible for the acquisition of fishing data (spotter pilots and vessel captains reports) and review and evaluation of all aspects of the investigation. The SEFC

responsibilities include program management and coordination, acquisition of fisheries data, and the development of models for predicting fish distribution from remote measurements of selected oceanographic parameters.

- 3.2 EXPERIMENTAL RATIONALE AND DESIGN. The rationale is based on the assumption that fish distribution is governed by certain measurable oceanographic parameters. The investigation was designed to identify these parameters and then to determine if they could be measured with sufficient accuracy remotely for fish distribution predictions. The parameters considered were limited to those that could be or had the potential of being remotely measured.
- 3.3 FIELD OPERATIONS. Field operations were organized and conducted to satisfy data requirements of the basic units of the experimental design. These operations functioned to provide aerospace remotely sensed data (LANDSAT and aircraft), oceanographic data (research vessels), fish distribution and abundance data (photographic and spotter pilot aircraft), and utilization data (fishing vessels). The primary parameters considered and the platforms from which measurements were made are presented in Figure 3.1.

Two classes of missions were conducted to satisfy the experimental design: main and supplementary. The main missions included all of the platforms shown in Figure 3.1 while the supplementary missions involved only fishing and LANDSAT data. The latter missions were designed to provide data for testing and expanding upon the oceanographic and fishery models developed from data acquired during the main missions.

The two study areas used in the investigation together with superimposed locations of LANDSAT tracks, NP3A, ERL Twin Beech, and NMFS charter aircraft flight lines, oceanographic sampling stations, and oil platforms are shown in Figures 3.2 and 3.3. Both study areas support an active menhaden fishery. Thread herring are primarily found in the offshore portions of the Louisiana study area although infrequently they are caught in the Mississippi Sound.

Figures 3.4 and 3.5 summarize the main and supplementary missions conducted in support of the investigation. The first two main missions in the Louisiana Test Site (Figure 3.4) operated as planned with all platforms acquiring data. The third scheduled mission, however, was aborted due to a reported LANDSAT-1 malfunction. It was rescheduled to coincide with a LANDSAT-2 orbit. The first two Mississippi Sound main missions also operated as planned while the third main mission had to be rescheduled due to inclement weather and unavailability of the NP3A aircraft (Figure 3.5). Unfortunately, even though the main and supplementary missions went smoothly from an operational standpoint, all LANDSAT MSS data are of marginal quality due to excessive cloud cover.

Figure 3.1 Main Day Mission Data Acquisition Platforms and Parameters

Parameter	SURFACE				AIRCRAFT					SATELLITES	
	Fish. Vess. without Observer	Fish. Vess. with Observer	Oceano- graphic Vessel	Oil Platform	NP3A	NASA ERL Aircraft	NFMOA Spotters	NMFS Photo	NMFS LLLTV*	LANDSAT	SMS/GOES
Salinity		X	X	X	X						
Chlorophyll		X	X	X	X*	X				X	
Color		X	X	X	X*	X				X	
Transparency		X	X	X	X*	X				X	
Temperature		X	X	X	X	X					
Water Depth		X	X	X							
Fish School Locations			X			X	X	X	X		
Location of Fish Catches	X	X				X		X			
Meteorology			X				X				X

*Louisiana study area only.

LANDSAT Gulf of Mexico Menhaden & Thread Herring Experiment - Louisiana

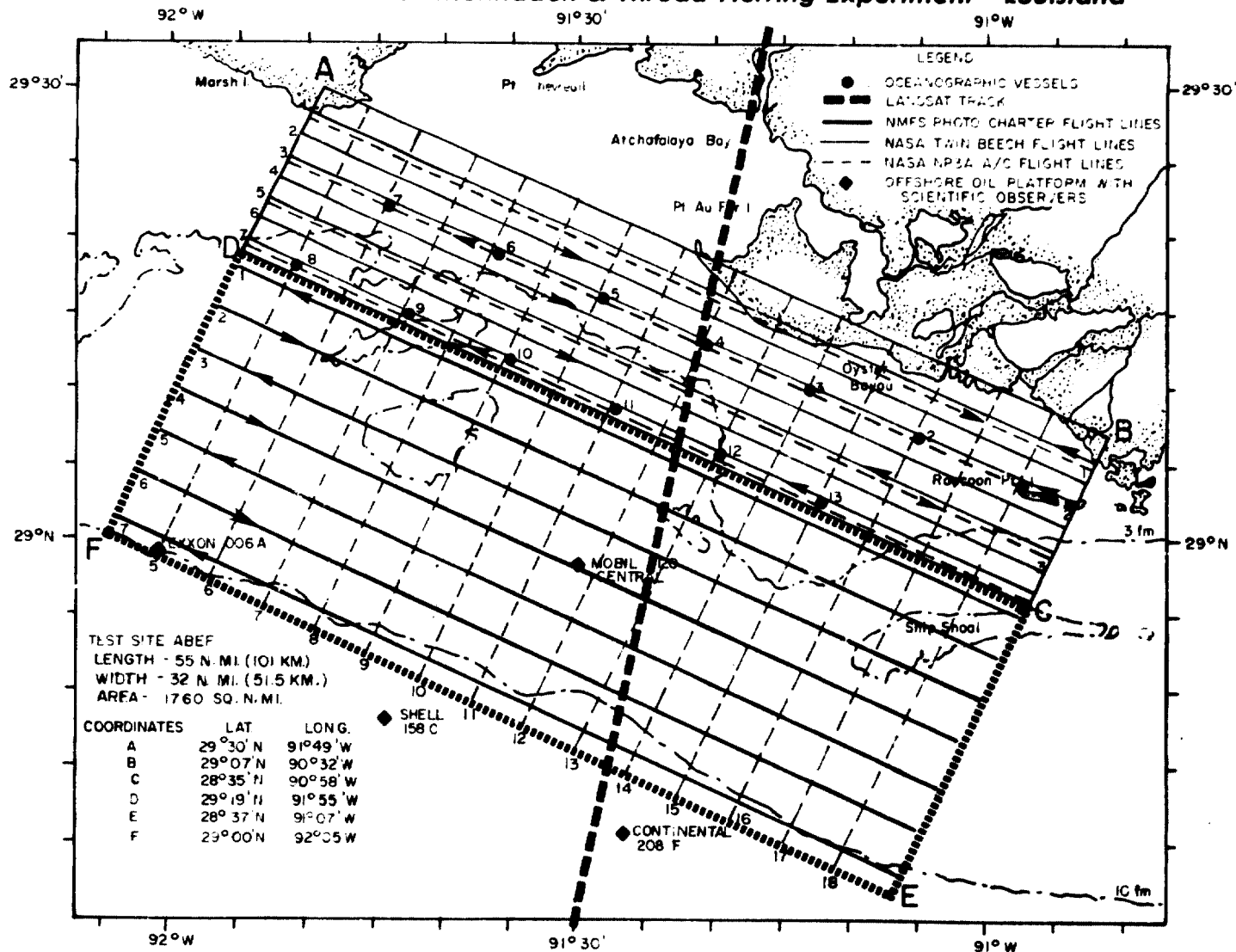


Figure 3.2 Louisiana Study Area Showing the LANDSAT Track, Aircraft Flight Lines, Oceanographic Stations, and Oil Platform Locations

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LANDSAT Gulf of Mexico Menhaden & Thread Herring Experiment - Mississippi Sound

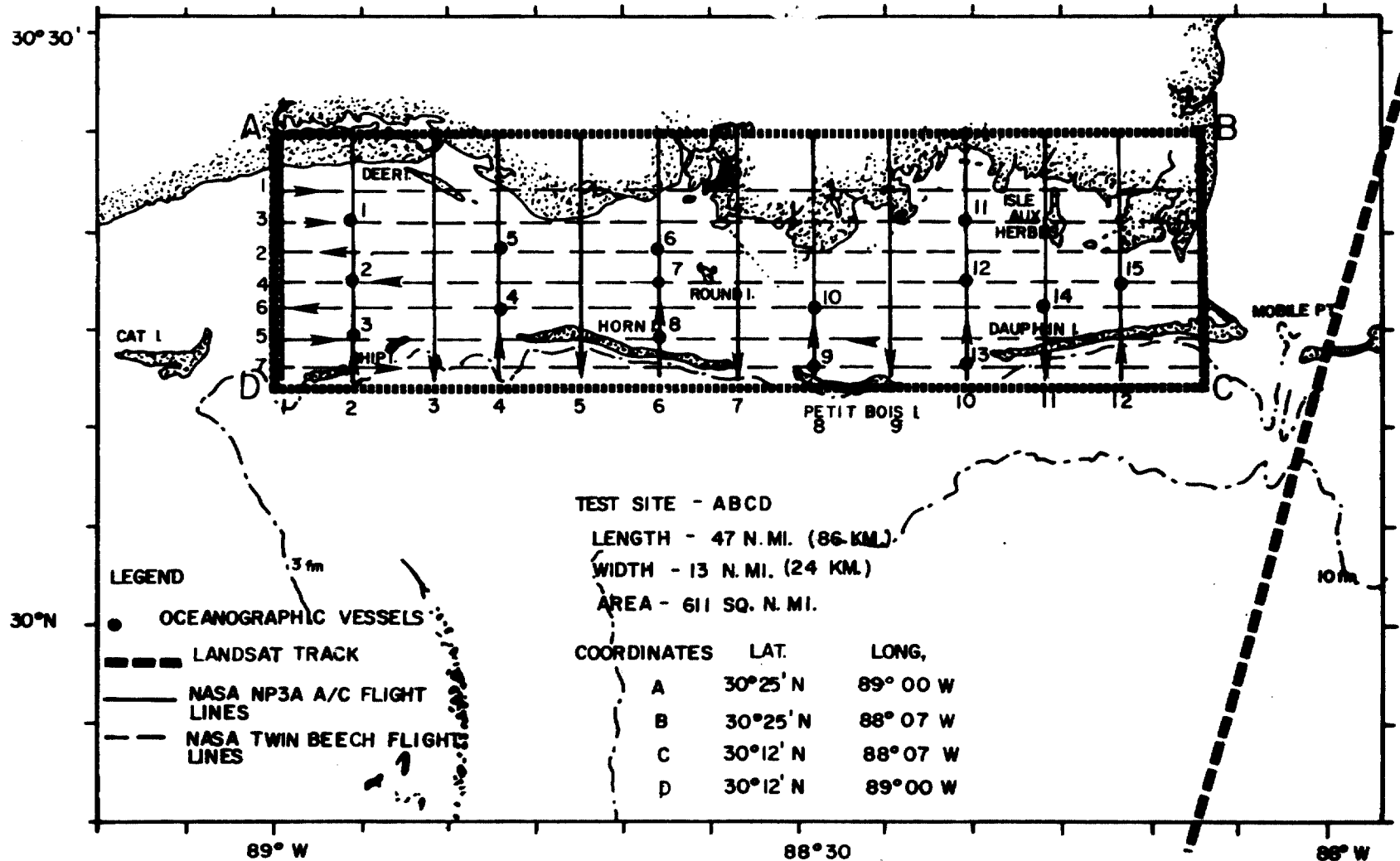


Figure 3.3 Mississippi Sound Study Area Showing the LANDSAT Track, Aircraft Flight Lines, and Oceanographic Stations

SUMMARY OF LOUISIANA LANDSAT MISSIONS (1975)

	MISSION	MAIN	MAIN	SUPPLE- MENTARY	ABORTED MAIN ¹	SUPPLE- MENTARY	RESCHED- ULED MAIN	SUPPLE- MENTARY	SUPPLE- MENTARY
PLATFORM	DATE	APR 25	MAY 13	JUN 18	JUL 24	AUG 11	AUG 20	AUG 29	SEP 16
FISHING VESSELS		X	X	X	X	X	X	X	X
SPOTTER AIRCRAFT		X	X	X	X	X	X	X	X
FISHING VESSEL OBSERVERS		X	X		X		X		
RESEARCH VESSELS		X	X				X		
OIL PLATFORMS		X	X				X		
ERL AIRCRAFT		X	X				X		
NP3A AIRCRAFT		X	X				X		
PHOTO- GRAPHIC AIRCRAFT		X	X				X		
LANDSAT I		X	X	X	X	X	X ²	X	X

¹ Mission aborted due to mechanical failure reported aboard LANDSAT I

² LANDSAT II

Figure 3.4 Summary of Louisiana Test Site Missions

SUMMARY OF MISSISSIPPI SOUND LANDSAT MISSIONS (1975)

Figure 3.5 Summary of Mississippi Sound Missions

PLATFORM	MISSION	MAIN	MAIN	SUPPLE- MENTARY	ABORTED MAIN 1	SUPPLE- MENTARY	MAIN ²	SUPPLE- MENTARY
	DATE	MAY 2	MAY 20	JUN 25	JUL 31	AUG 18	SEP 5	SEP 23
FISHING VESSELS		X	X	X	X	X	X	X
SPOTTER AIRCRAFT		X	X	X	X	X	X	X
FISHING VESSEL OBSERVERS		X	X		X		X	
RESEARCH VESSELS		X	X				X	
ERL AIRCRAFT		X	X					
NP3A AIRCRAFT		X	X				X	
LANDSAT II		X	X	X	X	X	X	X

1 Mission aborted due to inclement weather and unavailability of NP3A.

2 ERL Aircraft unable to complete mission due to inclement weather and mechanical failure.

- 3.4 DATA PROCESSING AND ANALYSIS. Emphasis for data processing has been given to reviewing available data for quality determinations and preparing it for insertion into a single LANDSAT data management system. The single system was developed to insure a complete data file for analytical purposes by current as well as future investigators.

Analytical emphasis initially was given to the sea truth data collected from fishing and research vessels. The objectives of these analyses were to identify those parameters and analytical techniques which offered the greatest potential for satisfying the objectives of the investigation. The analytical rationale was to compare oceanographic measurements at sites of menhaden capture with those taken from the research vessels over time and between test sites. This was done to determine if menhaden appeared to prefer a relatively constant range of environmental conditions. The assumption was that those parameters remaining relatively constant in magnitude, but demonstrating differences from those measured from the research vessels could be used to predict fish distribution.

The parameters which appeared to have significant direct effects on menhaden distribution are water turbidity (secchi disc) and color (Forel-Ule). Surface water temperature and salinity appeared to have little direct effect.

A major feature of the analytical efforts is they emphasize May 20, 1975, a main mission day for the Mississippi Sound. The rationale was to select one mission for emphasis such that all remotely acquired data (temperature, salinity, and LANDSAT color) could be processed for analysis along with all of the sea truth and fishing data.

4. ACCOMPLISHMENTS

- 4.1 DATA PROCESSING. The status of the LANDSAT Data flow is shown in Figures 4.1 through 4.6. In addition, computer tabulations of fishing vessel data, spotter pilot data, oceanographic vessel data, and oil platform data have been prepared to be used in an interim data report and ongoing data analysis.

Recent data processing efforts have been concentrated on data from the May 20, 1975 Mississippi Sound mission. Computer point plots including land mass displays have been developed for remotely sensed PRT-5 temperatures and salinity, and sea truth measurements of surface temperature, surface salinity, surface chlorophyll-a, Secchi depth, Forel-Ule color, and water depth. A computer display of fish locations (aerial photography and fishing vessel and spotter aircraft reports) for May 20 has been completed. The scaled display was converted to a clear overlay which is being used to selectively retrieve point values for each of the above parameters at locations with and without fish.

LANDSAT DATA FLOW

Mission No. 1

Date 25 April

SURFACE TRUTH

Site Louisiana

Platform	Data Type	Data Acq.	Data Rec.	Data Veri.	Data Trans.	Data Veri.	Key Punched	Data Ret.	Data Veri.	Data to Comp.	Data Ret.	Data Anal.
Fishing Vessel	Fish Data	X	X	X	X	X	X	X	X	X	X	
	Oceano. Data	X	X	X	X	X	X	X	X	X	X	
Spotter Pilot	Fish Data	X	X	X	X	X	X	X	X	X	X	
Oceano. Vessel	Oceano. Data	X	X	X	X	X	X	X	X	X	X	
Oil Platform	Oceano. Data	X	X	X	X	X	X	X	X	X	X	
NMFS A/C Charter (photo)	Fish Loc. Data	X	X	X								
NASA Twin Beech	Fish Photo Data, KC1B	X	X	X	X	X	X					

REMOTE SENSING

Platform	Data Type	Data Acq.	Data Rec.	Quick Look	A/D, Decom. or Refo.	Raw Product	Correl. w/ Surf. Truth	Final Data Prod.	Sample Extract.	Data to Comp.	Data Ret.	Data Anal.
NASA Twin Beech	RS-18	X	X	X								
	PRT-5	No										
NASA NP3A A/C	MFMR	X	Partial									
	M ² S	Yes	X	X								
	PRT-5	X										
LANDSAT	Imagery	X	X	X	NA	X						
	CCT	X	X	X	X	X						

Figure 4.1 Platform and Data Flow Status Summary for the April 25, 1975 Louisiana Main Day Mission

LANDSAT DATA FLOW

Mission No. 2

Date 2 May

SURFACE TRUTH

Site Mississippi Sound

Platform	Data Type	Data Acq.	Data Rec.	Data Veri.	Data Trans.	Data Veri.	Key Punched	Data Ret.	Data Veri.	Data to Comp.	Data Ret.	Data Anal.
Fishing Vessel	Fish Data	X	X	X	X	X	X	X	X	X	X	
	Oceano. Data	X	X	X	X	X	X	X	X	X	X	
Spotter Pilot	Fish Data	X	X	X	X	X	X	X	X	X	X	
Oceano. Vessel	Oceano. Data	X	X	X	X	X	X	X	X	X	X	
NASA Twin Beech	Fish Photo Data, KC1B	X	X	X	X	X	X	X	X	X	X	

REMOTE SENSING

Platform	Data Type	Data Acq.	Data Rec.	Quick Look	A/D, Decom. or Refor	Raw Product	Correl. w/ Surf. Truth	Final Data Prod.	Sample Extract	Data to Comp.	Data Ret.	Data Anal.
NASA Twin Beech	RS-18	X	X	X	Partial	X						
	PRT-5	X	X	X	X	X	X	X	X	X	X	
NASA NP3A A/C	MFMR	X	X	X	NA	NA						
	M ² S	No										
	PRT-5	X										
LANDSAT	Imagery	X	X	X	NA	X						
	CCT	X	Not Ordered									

Figure 4.2 Platform and Data Flow Status Summary for the May 2, 1975 Mississippi Sound Main Day Mission

LANDSAT DATA FLOW

Mission No. 3

Date 13 May

SURFACE TRUTH

Site Louisiana

Platform	Data Type	Data Acq.	Data Rec.	Data Veri.	Data Trans.	Data Veri.	Key Punched	Data Ret.	Data Veri.	Data to Comp.	Data Ret.	Data Anal.
Fishing Vessel	Fish Data	X	X	X	X	X	X	X	X	X	X	
	Oceano. Data	X	X	X	X	X	X	X	X			
Spotter Pilot	Fish Data	X	X	X	X	X	X	X	X	X	X	
Oceano. Vessel	Oceano. Data	X	X	X	X	X	X	X	X	X	X	
Oil Platform	Oceano. Data	X	X	X	X	X	X	X	X	X	X	
NMFS A/C Charter (photo)	Fish Loc. Data	X	X	X								
NASA Twin Beech	Fish Photo Data, KC1B	X	X	X	X	X	X					

REMOTE SENSING

Platform	Data Type	Data Acq.	Data Rec.	Quick Look	A/D, Decom. or Refo.	Raw Product	Correl. w/ Surf. Truth	Final Data Prod.	Sample Extract.	Data to Comp.	Data Ret.	Data Anal.
NASA Twin Beech	RS-18	X	X	X								
	PRT-5	X	X	X	X	X	X	X	X	X	X	
NASA NP3A A/C	MFMR	X	X									
	M ² S	X	X	X								
	PRT-5	X										
LANDSAT	Imagery	X	X	X	NA	X						
	CCT	X	X									

Figure 4.3 Platform and Data Flow Status Summary for the May 13, 1975 Louisiana Main Day Mission

LANDSAT DATA FLOW

Mission No. 4

Date 20 May

Site Mississippi Sound

SURFACE TRUTH

Platform	Data Type	Data Acq.	Data Rec.	Data Veri.	Data Trans.	Data Veri.	Key Punched	Data Ret.	Data Veri.	Data to Comp.	Data Ret.	Data Anal.
Fishing Vessel	Fish Data	X	X	X	X	X	X	X	X	X	X	
	Oceano. Data	X	X	X	X	X	X	X	X			
Spotter Pilot	Fish Data	X	X	X	X	X	X	X	X	X	X	
Oceano. Vessel	Oceano. Data	X	X	X	X	X	X	X	X	X	X	
NASA Twin Beech	Fish Photo Data, KC1B	X	X	X	X	X	X	X				

REMOTE SENSING

Platform	Data Type	Data Acq.	Data Rec.	Quick Look	A/D, Decom. or Refor.	Raw Product	Correl. w/ Surf. Truth	Final Data Prod.	Sample Extract	Data to Comp.	Data Ret.	Data Anal.
NASA Twin Beech	RS-18	X	X	X	X	X						
	PRT-5	X	X	X	X	X	X	X	X	X	X	
NASA NP3A A/C	MFNR	X	X	X	X	X	X	X	X			
	M ² S	No										
	PRT-5	X	X	X	X	X	X	X	X			
LANDSAT	Imagery	X	X	X	NA	X	X	X	X	NA	NA	X
	CCT	X	X	X	X	X	X	X	X	X	X	X

Figure 4.4 Platform and Data Flow Status Summary for the May 20, 1975 Mississippi Sound Main Day Mission

LANDSAT DATA FLOW

Mission No. 5

Date 20 August

Site Louisiana

SURFACE TRUTH

Platform	Data Type	Data Acq.	Data Rec.	Data Veri.	Data Trans.	Data Veri.	Key Punched	Data Ret.	Data Veri.	Data to Comp.	Data Ret.	Data Anal.
Fishing Vessel	Fish Data	X	X	X	X	X	X	X	X	X	X	
	Oceano. Data	X	X	X	X	X	X	X	X	X	X	
Spotter Pilot	Fish Data	X	X	X	X	X	X	X	X	X	X	
Oceano. Vessel	Oceano. Data	X	X	X	X	X	X	X	X	X	X	
Oil Platform	Oceano. Data	X	X	X	X	X	X	X	X	X	X	
NMFS A/C Charter (photo)	Fish Loc. Data	X	X	X								
NASA Twin Beech	Fish Photo Data, KC1B	X	X	X								

REMOTE SENSING

Platform	Data Type	Data Acq.	Data Rec.	Quick Look	A/D, Decom. or Refo.	Raw Product	Correl. w/ Surf. Truth	Final Data Prod.	Sample Extract.	Data to Comp.	Data Ret.	Data Anal.
NASA Twin Beech	RS-18	X	X	X								
	PRT-5	X	X	X	X	X	X	X	X	X	X	
NASA NP3A A/C	MFMR	X	X									
	M ² S	X	X									
	PRT-5	X										
LANDSAT	Imagery	X	X	X	NA	X						
	CCT	X	X	X								

Figure 4.5 Platform and Data Flow Status Summary for the August 20, 1975 Louisiana Test Site Main Day Mission

LANDSAT DATA FLOW

Mission No. 6

Date 5 September

SURFACE TRUTH

Site Mississippi Sound

Platform	Data Type	Data Acq.	Data Rec.	Data Veri.	Data Trans.	Data Veri.	Key Punched	Data Ret.	Data Veri.	Data to Comp.	Data Ret.	Data Anal.
Fishing Vessel	Fish Data	X	X	X	X	X	X	X	X	X	X	
	Oceano. Data	X	X	X	X	X	X	X	X	X	X	
Spotter Pilot	Fish Data	X	X	X	X	X	X	X	X	X	X	
Oceano. Vessel	Oceano. Data	X	X	X	X	X	X	X	X	X	X	
NASA Twin Beech	Fish Photo Data, KC1B	X	X									

REMOTE SENSING

Platform	Data Type	Data Acq.	Data Rec.	Quick Look	A/D, Decom. or Refor	Raw Product	Correl. w/ Surf. Truth	Final Data Prod.	Sample Extract	Data to Comp.	Data Ret.	Data Anal.
NASA Twin Beech	RS-18	No										
	PRT-5	No										
NASA NP3A A/C	MFMR	X	X									
	M ² S	No										
	PRT-5	X										
LANDSAT	Imagery	X										
	CCT	X										

Figure 4.6 Platform and Data Flow Status for the September 5, 1975 Mississippi Sound Main Day Mission

4.2 DATA ANALYSIS.

- 4.2.1 Salinity Measurements: Only data from May 20 have been analyzed to map surface salinity. While the L-band microwave data have been received for all missions, the PRT-5 thermal measurements which are required to convert the microwave emissivity data to salinity measurements have been received from JSC for only the May 20 mission. Shipment of the remaining PRT-5 data is expected in middle February.

The May 20 data are of excellent quality. While a major portion of the first and perhaps most important flight line was missing from the data tape supplied by JSC, adequate coverage was obtained. The accuracy of the remote salinity measurement is excellent, with a R.M.S. deviation from surface truth measurements of 1.41 ‰.

The most serious problem encountered in working with the microwave data so far has been in determining aircraft locations. Flight lines were not flown as designated in the Flight Request because of continuous difficulty with the navigation system. Boresight photography was of very poor quality, and as such is not very useful for plotting locations. As a result of these problems, positional accuracy is less than would normally be desirable, but is within acceptable limits for the four missions plotted to date. The final two data flights have not been plotted as the boresight photography has not yet been received.

- 4.2.2 LANDSAT Classification Analysis: Because water color, as measured by the fishing vessel observers with Forel-Ule color comparators, showed a strong correlation with fish distribution, application of statistical analyses to the multispectral scanner data was expected to correlate well also. The approach to explore this correlation was to attempt to use one of the Earth Resources Laboratory spectral pattern recognition techniques to classify the high probability fishing areas in the MSS data.

The locations of fish schools were determined from aerial photography, spotter aircraft reports, and fishing reports, and translated into the LANDSAT coordinate reference system. Radiance data were extracted from the computer compatible magnetic tapes (CCT's) for each of the school locations where clouds did not obscure the sea surface. An additional restriction that the school had been located within two hours of the satellite passage was imposed. Areas where no fish schools were observed during the entire day of the mission were also identified, and radiance data were extracted from the CCT's for these areas as well. These areas are referred to as training sites and together make up the training set. Statistical analysis indicated that the resulting "fish" and "no fish" categories were separable on the basis of water color as measured by the LANDSAT MSS despite the fact that spectral bandwidths were not optimized for this type work.

The classifier used in the analysis functions by comparing the radiance in each channel to a predetermined range for that channel. If the radiance values for each channel are within the prescribed ranges, the individual picture element is classified. All other elements remain unclassified, and are assigned an output value scaled from the average of the four channels. Classified elements are assigned a value of zero. The data are preprocessed from the original CCT to remove the problems resulting from inconsistent calibration of the six detectors in each channel and to improve the radiometric resolution of the data. This is accomplished by averaging each channel over a six scan line by seven element wide matrix across the entire data set, and multiplying the resulting averages by 4. This increases the range of values from 0 to 63 to 0 to 252, improving the radiometric resolution by a factor of four, since all work is performed in the integer mode. The sacrifice of spatial resolution is not critical, as water features tend to be relatively smoothly varying wider areas. During the preprocessing, a land/water discriminator is applied to the data and all picture elements determined to be land are assigned a value of 255. Additional details concerning the classification procedure and the preprocessing are available from ERL and will be published in a later report on this experiment.

With the classification range in each of the channels set to the mean plus or minus the standard deviation of the entire set of picture elements associated with the training set of fish schools, the preprocessed data from May 20 were analyzed. Twenty-five of the schools were found within or immediately adjacent to areas classified as high probability fishing areas, while four were not. Nineteen additional schools had been located on the day of the mission, but outside the allocated time window. Of these, sixteen were within or immediately adjacent to the classified fish areas, with only three falling in other water.

Data acquired during the 1972-73 menhaden experiment were analyzed similarly. School positions were not so precise, as they were archived on a half-mile reference grid. Analysis of these data resulted in classification of almost the entire western portion of the Mississippi Sound as being high probability fishing area. The approach was modified slightly when statistical analysis of the data indicated that the standard deviation of all the individual picture elements making up the training set included high spatial frequency noise that was eliminated by the preprocessing. The limits of the classification range were then set to the mean of all the points within the training set plus or minus the standard deviation of means of the individual training sites. Table 4.1 contains both sets of limits for comparison purposes. The result of the new classification was more acceptable, indicating only 15% of the Sound being classified as high probability fishing areas. The change in the method of determining the classification ranges has a very small effect on the limits set for May 20.

A new classification has not yet been developed to evaluate the effects quantitatively, nor has the accuracy of the 1972 data been fully determined. Preliminary indications are that the second 1972 classification is very good.

Table 4.1

20 May 1975

	Channel 4		Channel 5		Channel 6		Channel 7	
	Low	High	Low	High	Low	High	Low	High
A	95	108	84	97	45	58	4	10
B	95	108	84	96	46	57	6	9

7 August 1972

	Channel 4		Channel 5		Channel 6		Channel 7	
	Low	High	Low	High	Low	High	Low	High
A	120	128	81	90	48	55	11	16
B	122	126	83	88	59	53	13	14

A: mean plus or minus standard deviation of entire training set

B: mean plus or minus standard deviation of means of individual sets

- 4.2.3 LANDSAT Statistical Analysis: LANDSAT MSS data from the May 20th Mississippi Sound main mission were reduced and analyzed relative to locations with and without menhaden. Initial analyses were concerned with trying to identify which spectral channels correlated with menhaden locations and roughly the magnitude of the relationships.

Mean radiance values (in counts) in each of the four LANDSAT MSS channels from 22 with and 20 without menhaden were processed through a step-wise multiple regression computer program using fish distribution as the dependent variable. The results are shown in Table 4.2.

Table 4.2 Correlation Between LANDSAT Spectral Channels and Menhaden Distribution

Parameter	Degrees of Freedom	Correlation Coefficient (r) Menhaden Distribution
Channel 4 (in counts)	40	.401**
Channel 5 (in counts)	40	.484**
Channel 6 (in counts)	40	.496**
Channel 7 (in counts)	40	.511**

** Significant at the 99% confidence level

The computer program was run to completion and a predictive model was produced of the form:

$$D_c = 0.81 - 0.05C_4 + 0.17C_5 - 0.20C_6 + 0.80C_7$$

Where:

D_c = Fish distribution (0 = absent; 1 = present)

C_i = Spectral Channel (4, 5, 6, or 7)

The model was based on 42 samples and was significant at the 99% level of confidence. The correlation coefficient of the model was 0.54 and its standard error was 0.45. Channels 5 and 7 accounted for most of the explained variation in the data.

Additional computations and analyses were done to determine if combinations of the four channels or some non-linear form of a channel would correlate better with menhaden distribution. All possible product combinations of the four channels (e.g. $C_4 \times C_5$) as well as second, third, and fourth powers of each channel were computed and used along with the original data from each channel. This resulted in regressing 27 parameters against menhaden distribution (D_{cp}). The correlation coefficients ranged from .393 to .515, all of which were significant at the 99.5% level. Again the program was run to completion to generate a prediction model D_{cp} of the form:

$$C_{cp} = 2.80 - 0.63C_5 + 7.77C_7 - 0.06C_5C_7 - 1.33C_7^3 + 0.28C_7^4$$

Where the nomenclature is the same as before. The sample size remained 42 and the model was significant at the 99 % confidence level. The standard error of the model was 0.42 and the correlation coefficient was 0.64.

- 4.2.4 Sea Truth: Comparisons of chlorophyll-a concentrations at sites of menhaden capture and oceanographic sampling stations over time are presented in Figures 4.7 and 4.8 for the Louisiana and Mississippi Sound study areas, respectively. A between study area comparison of this parameter is presented in Figure 4.9 along with summaries of the other measured parameters at sites of menhaden capture.

Chlorophyll does not appear to be a very good indicator of menhaden distribution based on the histograms presented in Figures 4.7 and 4.8. The ranges of chlorophyll concentrations measured from the fishing vessels were very similar to the ranges reported from the research vessels. The ranges, however, were surprisingly similar for the two study areas.

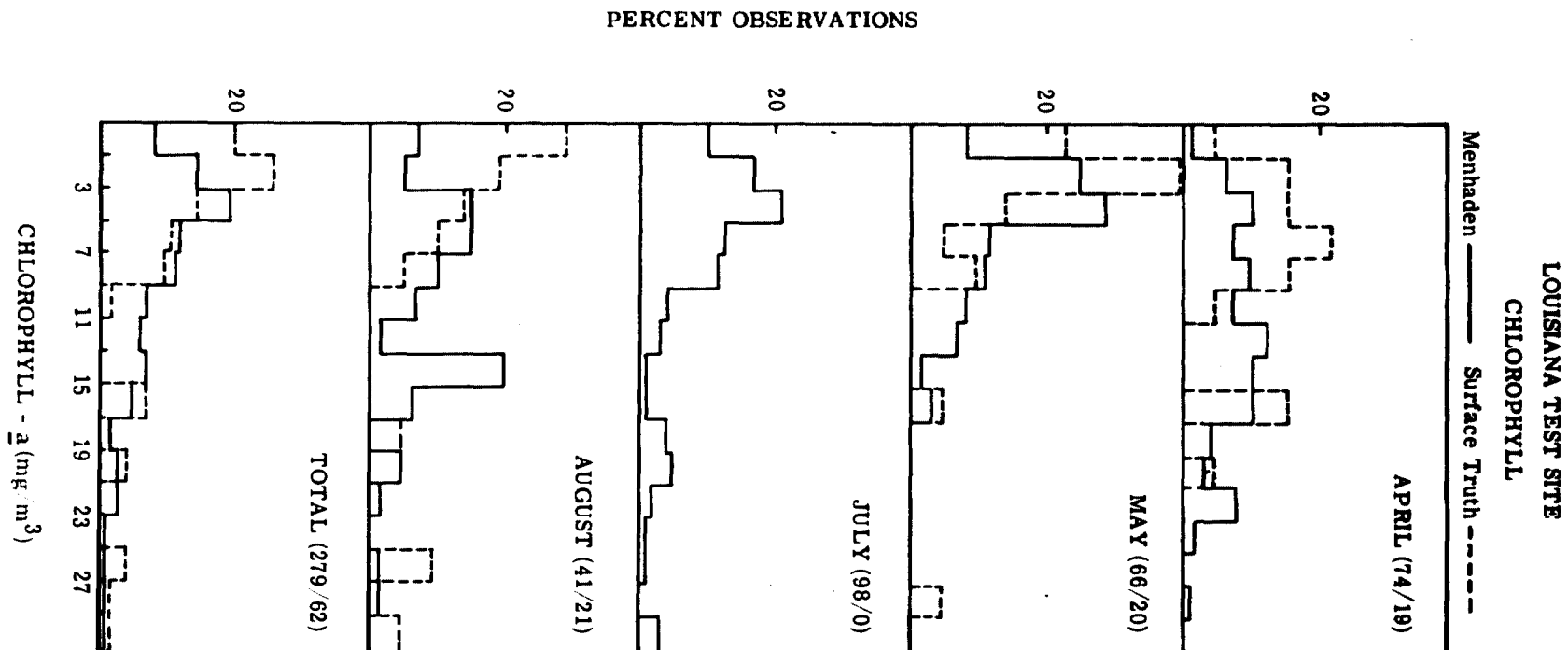


Figure 4.7 Comparison of Surface Measurements of Chlorophyll-a from Sites of Menhaden Capture (Solid Lines) and Oceanographic Stations (Broken Lines) in the Louisiana Test Site. Sample size is given in parenthesis with the first number indicating the number of samplings from sites of menhaden capture.

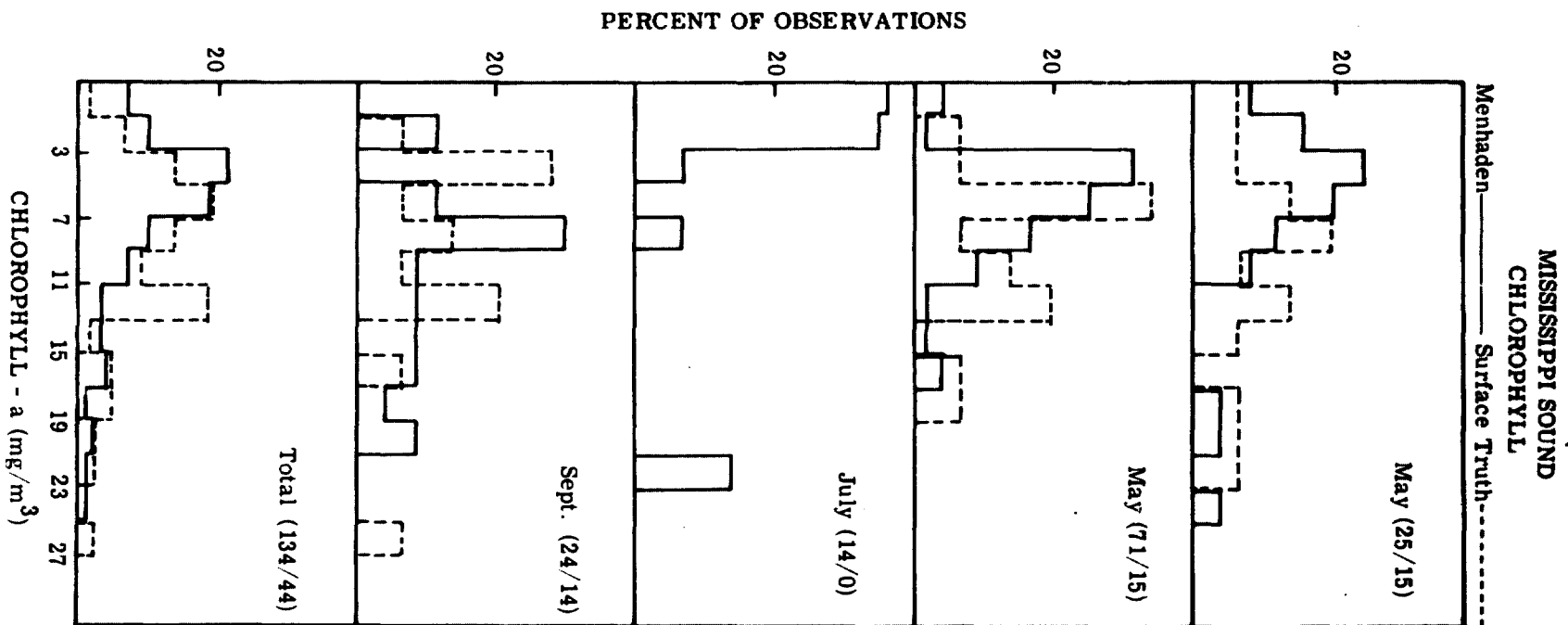


Figure 4.8 Comparison of Surface Measurements of Chlorophyll-a from Sites of Menhaden Capture (Solid Lines) and Oceanographic Stations (Broken Lines) in the Mississippi Sound Test Site. Sample size is given in parenthesis with the first number indicating samples from sites of menhaden capture.

COMPARISON OF CONDITIONS BETWEEN TEST SITES
WHERE MENHADEN WERE CAUGHT

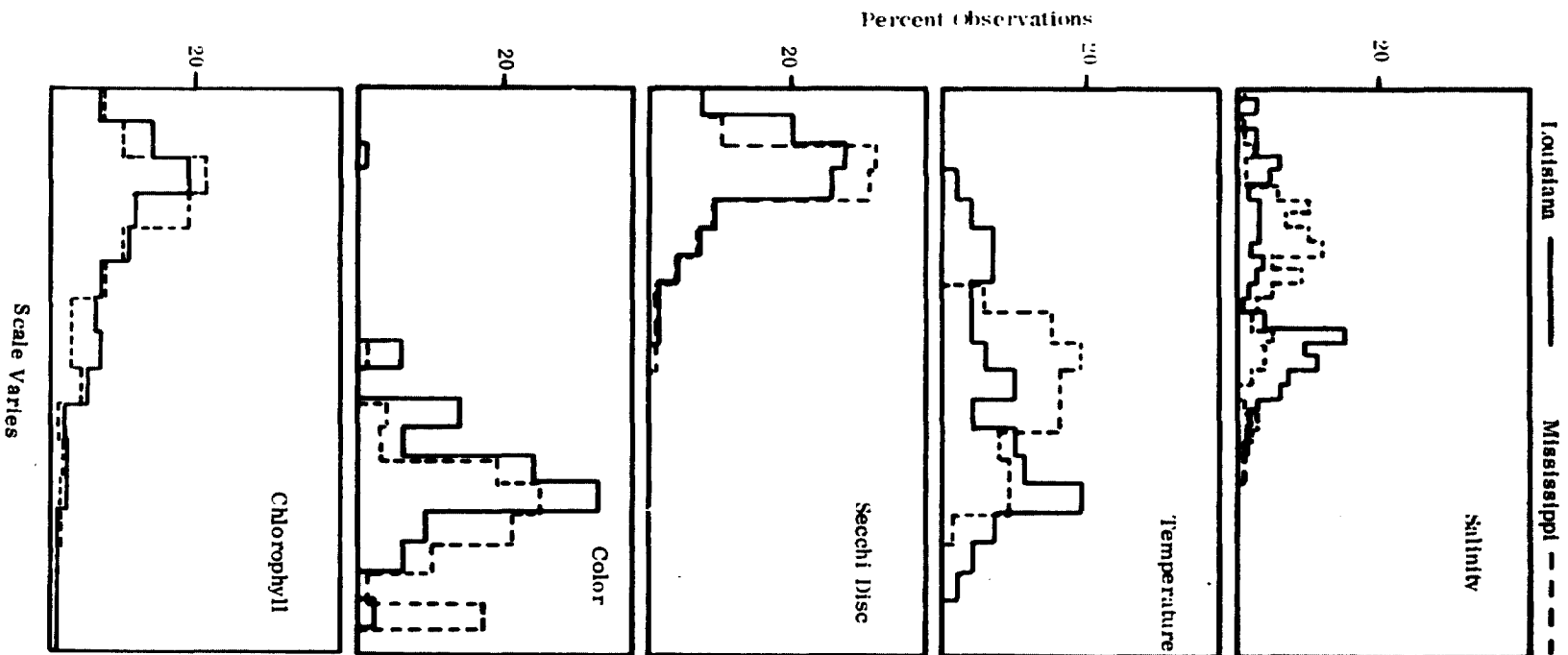


Figure 4.9 Summary of Measurements Taken at Sites of Menhaden
Capture for the Two Study Areas

- 4.3 FUTURE PLANS: Emphasis for the next several months will be given to continued analysis of LANDSAT MSS data for charting high probability fishing areas. Special attention will be given to the Louisiana, July 24th aborted main mission. This mission is probably the best one available for Louisiana in terms of LANDSAT and fishing data. Other supplementary missions also will be emphasized in this analysis.

An attempt will also be made over the next few months to develop a signature extension algorithm for LANDSAT data. The objective is to develop a mechanism whereby a single set of training fields taken from one LANDSAT CCT can be used to classify all subsequent LANDSAT data into high and low probability fishing areas.

Remote measurements of salinity and temperature will be combined with LANDSAT MSS data to determine if they will significantly improve the precision of models developed solely from MSS data. When LANDSAT data are unavailable due to cloud contamination, RS-18MS color data may be used instead.

5. SIGNIFICANT RESULTS

The most significant achievement realized by this investigation thus far is the successful mapping of high probability fishing areas from LANDSAT MSS data for two Mississippi Sound missions. Future efforts will continue to explore the apparent relationship between water color and menhaden distribution.

6. REPORTS, PUBLICATIONS AND MEETINGS

One formal report was prepared by ERL which directly relates to the investigation:

"LANDSAT Menhaden-Thread Herring Resource Investigation;
Surface Measurement Report," ERL Report Number 154,
December 1975.

A manuscript entitled "An Operational Overview of the LANDSAT Menhaden and Thread Herring Investigation" was prepared for presentation at the Eighth Annual Offshore Technology Conference, Houston, Texas, May 3-6, 1976. An abstract of the manuscript follows:

A 22-month investigation is being conducted cooperatively by private fishing industry and the Federal government to demonstrate the feasibility of using satellite (LANDSAT) data for enhancing the management and utilization of coastal fishery resources in the northern Gulf of Mexico.

Menhaden (Brevoortia patronus) and thread herring (Opisthonema oglinum) were selected as target species in the study areas located in the Mississippi Sound and off the Louisiana coast. Three main data acquisition missions were planned for each test area. The missions include satellite and aircraft remote sensing and in situ sampling of oceanographic parameters from oil platforms and research vessels. Fish school location surveys were conducted from fishing industry spotter aircraft, and in situ oceanographic sampling coincident with fish catches were made by observers aboard the commercial fishing fleet.

Synoptic sea truth data were obtained from surface platforms for correlation with data obtained from remote sensing aircraft and satellites. This investigation is expected to produce a valuable source of information to augment our knowledge of the coastal water ecology and provide new remote sensing and data management techniques.

Several meetings were attended where reviews of the LANDSAT Investigation were presented:

November 5: A briefing covering the investigation was given at the Second NMFS Remote Sensing Workshop in Monterey, California.

November 12: A review of the field operations phase of the investigation was presented at the Executive Session of the NFMOA meeting in Biloxi, Mississippi.

November: A discussion of current water color analyses associated with the LANDSAT Investigation was given at a NASA Water Color Workshop at NSTL.

7. PROBLEMS

Clouds continue to interfere with the analysis of LANDSAT MSS data. This is particularly frustrating because of the apparent strong relationship between the spectral channels and menhaden distribution. Fortunately, only one main mission out of the attempted six appears to be a total loss.

The recent relocation of ERL from NSTL to Slidell has caused a delay in some of the analysis, especially those relating to LANDSAT MSS data. This delay, however, is only temporary and expectations are that it will be over shortly.

8. RECOMMENDATIONS

No recommendations are presented at this time.

9. FUNDS EXPENDED

Purchase orders and other expenditure directly attributable to this investigation total \$183,288.00. This amount is less than last reported due to a contract being less than anticipated and travel costs being less than shown on travel orders.

10. LANDSAT DATA

Table 10.1 summarizes LANDSAT 1 and 2 ordered in support of this investigation. These data are being used to establish relationships between the distribution of menhaden and thread herring and their ocean environment as manifested in the LANDSAT spectral channels.

Table 10.1 Summary of LANDSAT Data Status

Mission Date	Satellite	Ident. Code	Data Quality	Value of Data Ordered (\$)		
				9"x9" Transparency		
				Pos.	Neg.	CCT
April 25	I	5006-15485	Fair	20	24	200
May 2	II	2100-15445	Poor	20	24	-
May 13	I	5024-15480	Fair	20	24	-
May 20	II	2118-15448	Good	20	24	200
May 21	II	5024-15473	Good	20	24	-
June 18	I	?	Not Received	20	24	-
June 25	II	2154-15450	Excellent	20	24	200
July 24	I	5096-15435	Good	20	24	200
July 31	II	2190-15442	Not Received	20	24	-
August 11	I	?	Not Received	20	24	-
August 18	II	2208-15435	Excellent	20	24	-
August 20	II	2210-15554	Poor	20	24	200
Sept 5	II	?	Not Received	20	24	-
Sept 16	I	?	Not Received	20	24	-
Sept 23	II	?	Not Received	20	24	-
TOTALS				300	360	1,000
GRAND TOTAL						1,600

11. AIRCRAFT DATA

Table 11.1 summarizes the status of data acquired with sensors aboard the NP3A. These data are primarily being used for computing salinity conditions in the two test sites.

Table 11.1 Aircraft Data (NP3A) Status

Mission Date 1975	Microwave		PRT-5		M ² S		Photography (Boresight)	
	<u>Status</u>	<u>Quality</u>	<u>Status</u>	<u>Quality</u>	<u>Status</u>	<u>Quality</u>	<u>Status</u>	<u>Quality</u>
April 25	In lab	?	Not rec'd	?	In lab	?	In lab	Poor
May 2	In lab	Adequate	Not rec'd	?	NA	NA	In lab	Poor
May 13	In lab	?	Not rec'd	?	In lab	Good	In lab	Poor
May 20	In lab	Good	In lab	Good	NA	NA	In lab	Poor
July 24	NA	NA	NA	NA	NA	NA	NA	NA
July 31	NA	NA	NA	NA	NA	NA	NA	NA
August 20	In lab	?	Not rec'd	?	In lab	Good	Not rec'd	?
Sept 5	In lab	?	Not rec'd	?	NA	NA	Not rec'd	?